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SOME GEOLOGICAL STUDIES ON NORTHWESTERN WASHINGTON AND ADJACENT BRITISH TERRITORY.

By ALBERT B. REAGAN, Mora, Wash.

THE region under consideration extends in a north and south direction from the city of Bellingham north to the Fraser river in British Columbia; and in an east and west direction from the foot-hills of the Sumas and Selkirk mountains to Georgian Bay. For the most part its practically low, level surface consists of estuary and glacial deposits, some trap and granite rock, and a small patch of Eocene exposed in British Columbia and a larger patch of Eocene at Bellingham. The whole region was once heavily timbered, but now, on the southern side of the international boundary-line, it is about half cleared and the other part might be termed "logged off" lands, as the best timber has been cut. And now railways and wagon roads traverse it in all directions. The area in British Columbia is still in the virgin state, with the exceptions of a few clearings here and there. In the Fraser delta, however, there are large areas of cleared land. At places it is thickly settled. Also large cities are on the river here. The cleared lands are valued at from $60 to $120 per acre; the "logged off" lands on the American side, $10 per acre. The region is a difficult one in which to trace out geological formations in detail. Only a reconnoisance trip was made in British territory.

LITERATURE.

In volume I of the Washington Geological Survey, Prof. Henry Landes, state geologist, describes the region in the vicinity of Bellingham, giving the resources of the same in detail. A further mention of his work will be given when the subjects concerned are considered.

STRATIGRAPHICAL SECTIONS.

1. Section at the water's edge one-half mile south of Fish Point:

1.	Dark brown sand, containing layers of oyster shells, which seem to indicate that the deposit had evidently been at least a tide-water beach.	1 foot.
2.	Light brown sand tinged occasionally with ocher	10 feet.
3.	Blue ground moraine clay, containing small water-worn granite fragments, also large granite boulders of glacial origin, as is demonstrated by parallel scratches and by one face of the boulders being flattened	14 "

2. Section on Bellingham bay, one and one-half miles south of Fish Point:

1.	Black earth	6 feet.
2.	Yellow clay, containing round fragments	8 “
3.	Sand	10 “
4.	Coarse gravel, cobblestones, and sand—an occasional large boulder—all promiscuously mixed, apparently outwash material at the foot of the glacier. Occasional sorting is shown	20 feet.

3. Section 300 feet south of section 2:

1.	Alluvium	4 feet.
2.	Yellow clay and sand	14 “
3.	Very coarse gravel, containing many cobblestones	10 “
4.	Banded coarse sand	16 “

4. Section 300 feet south of section 3:

1.	Alluvium	4 feet.
2.	Yellow sand	10 “
3.	Gravelly sand	10 “
4.	Laminated coarse sand	14 “
5.	Coarse gravel	4 “
6.	Light brown, massive, very fine sand	3 “

5. Section 300 feet south of section 4:

1.	Alluvium	4 feet.
2.	Yellow sand	14 “
3.	Light brown, fine sand	10 inches.
4.	Coarse, laminated sand, with laminæ dipping south 45 degrees	16 feet.
5.	Coarse, laminated sand	8 inches.
6.	Coarse gravel, bedded, with beds dipping south at an angle of 45 degrees	4 feet.
7.	Not seen	4 “

6. Section 600 feet south of section 5:

1.	Alluvium	4 feet.
2.	Yellow sand	14 “
3.	Massive dark brown sand, containing rounded and angular fragments	28 “

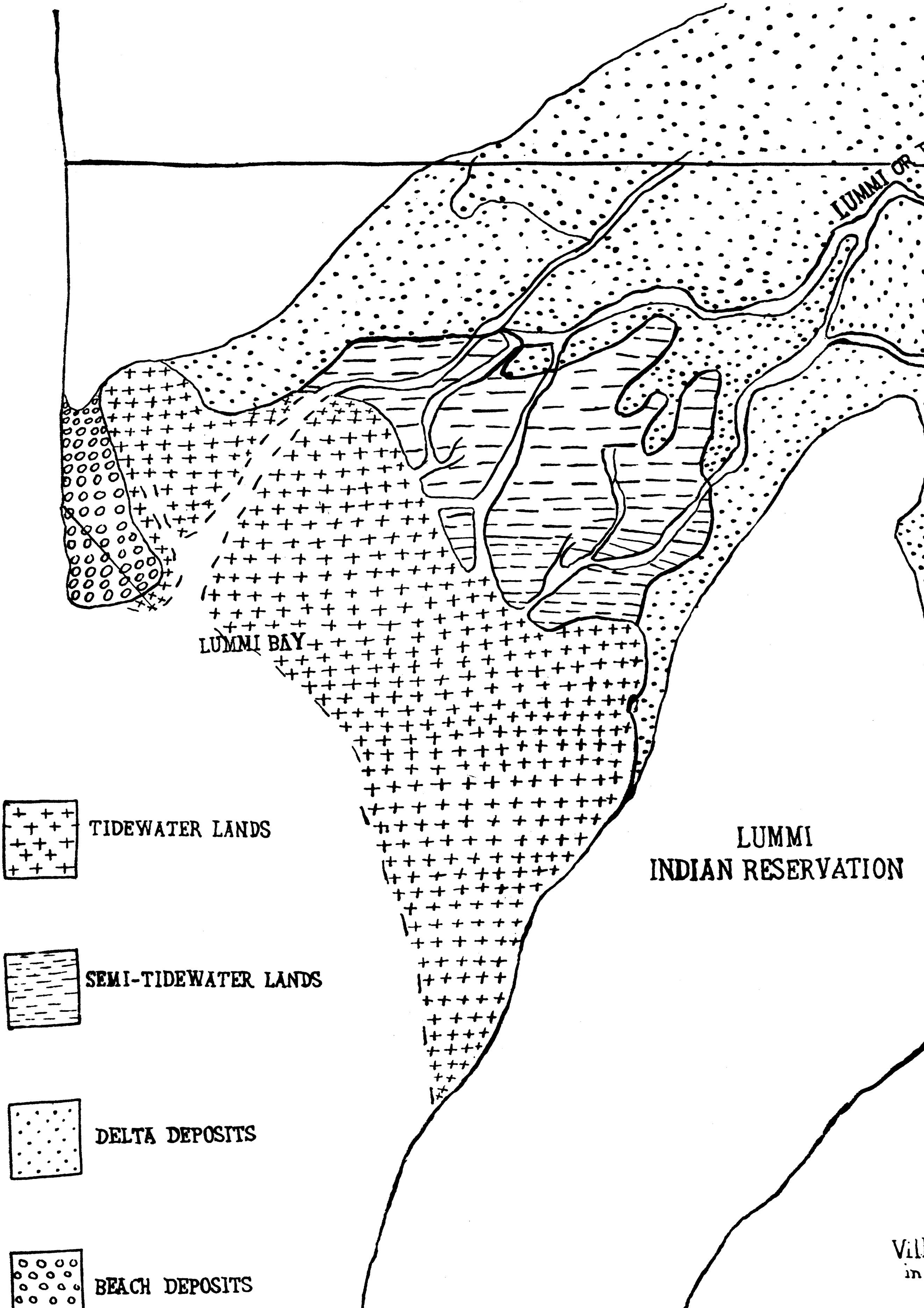
7. Section 300 yards south of section 6:

1.	Sand	10 feet.
2.	Blue clay, containing large boulders. In this stratum there are *Pecten* and other marine shells	30 “

8. Section 600 feet south of section 7:

1.	Yellow sand	20 feet.
2.	Laminated blue clay	2 “
3.	Massive blue clay (*Pecten* shells)	2 “

Sections 2–8 are extraglacial deposits of the narrow moraine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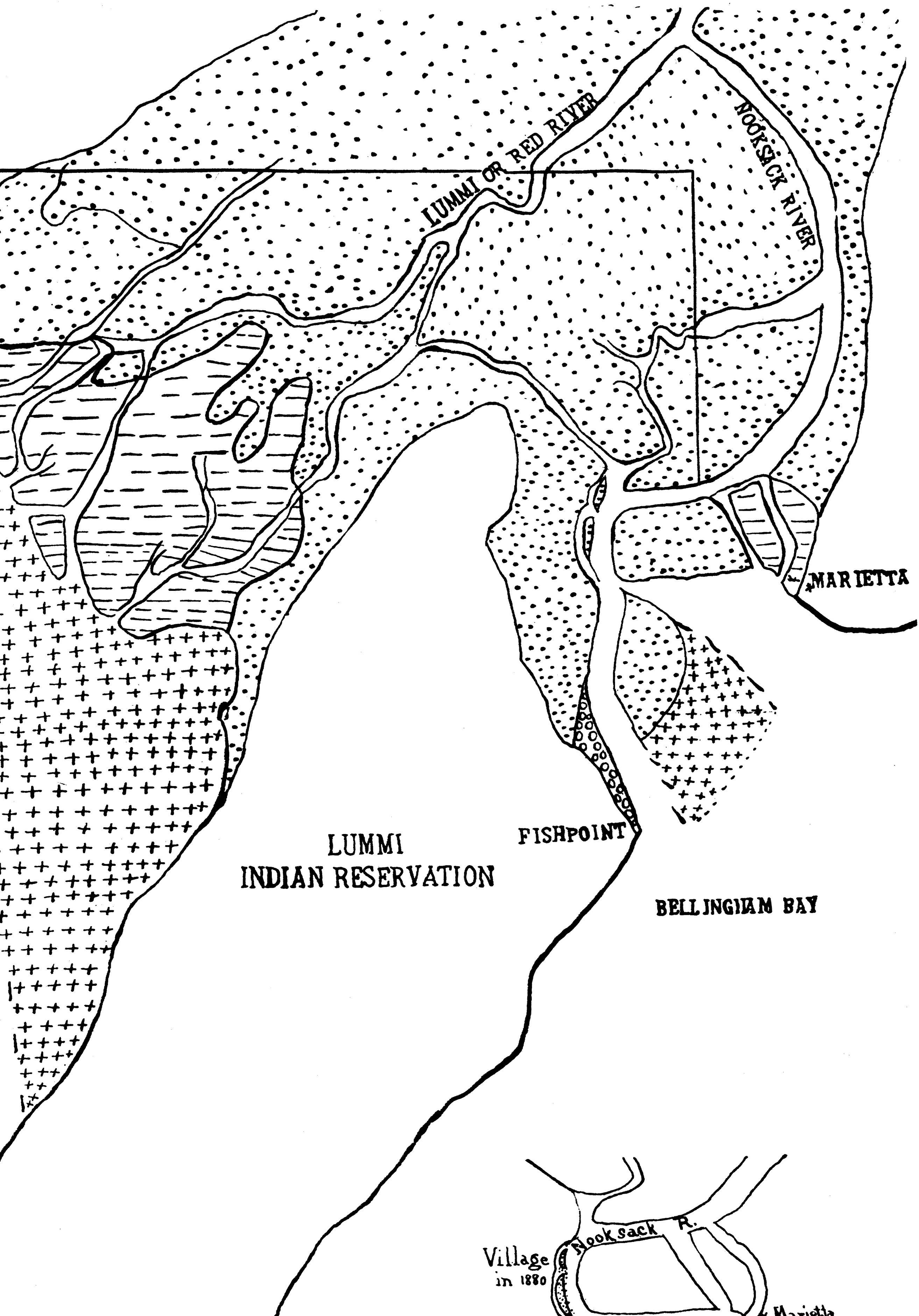
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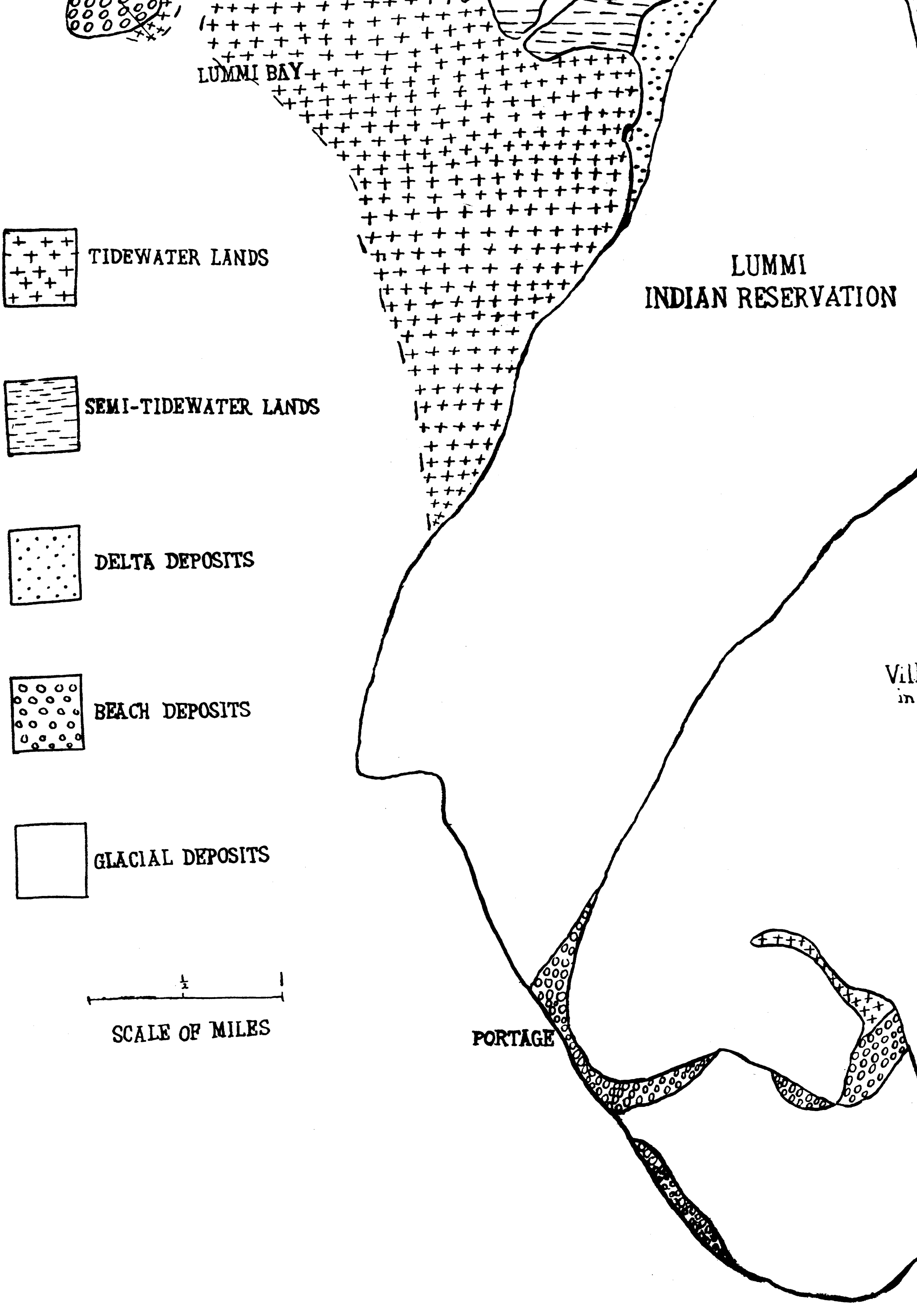
Nooksack R.
Village in 1880
Marietta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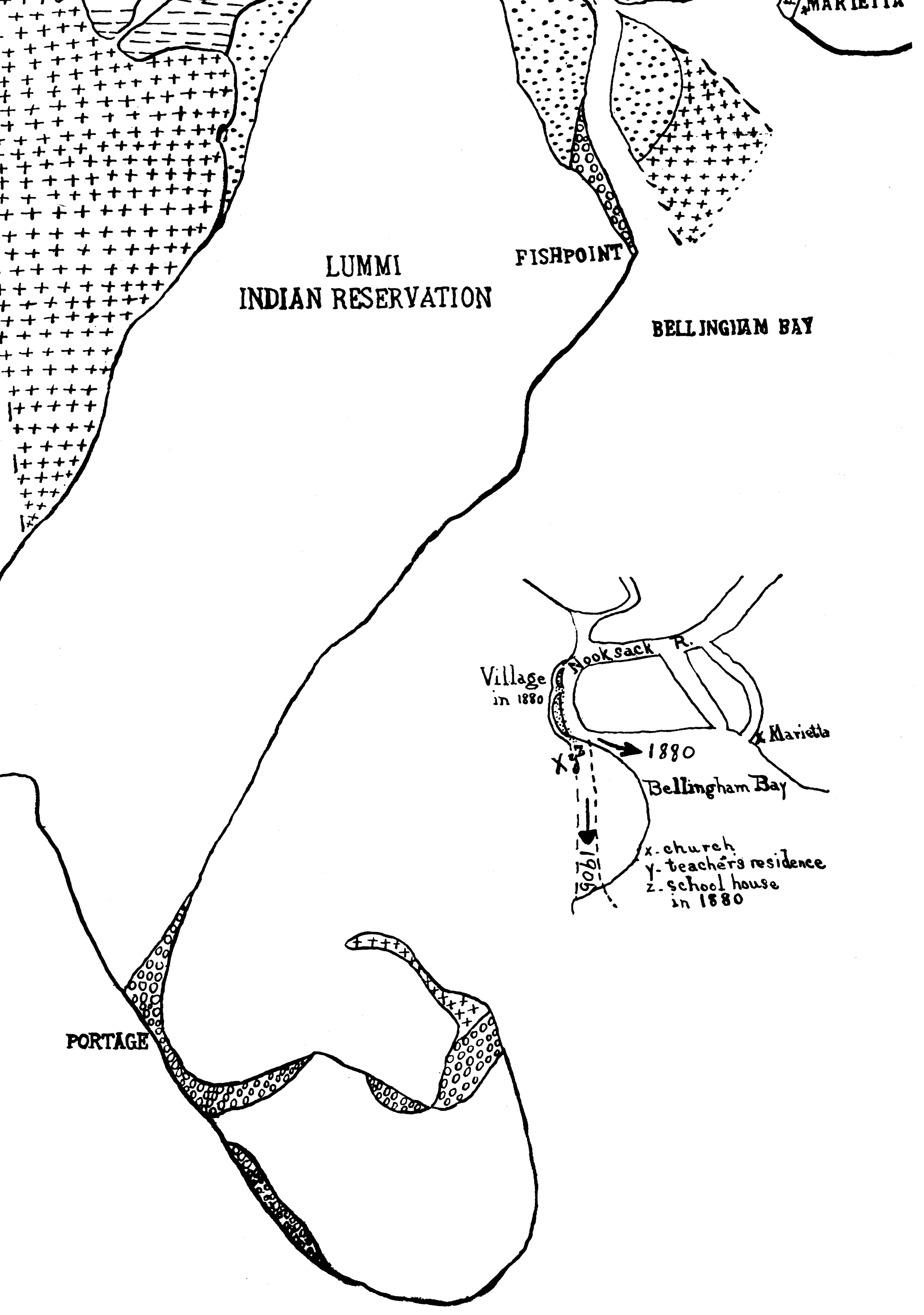
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Nooksack R.
Village
in 1880
Marietta
X y z
1880
Bellingham Bay
1909
x. church
y. teachers residence
z. school house
in 1880

delta type. They were apparently deposited at the mouth of an osar stream.

In section 5, opposite the mouth of the above glacial stream a glacial foot maintained itself for a considerable time. Later it was pushed further south. That the terminal moraine was at this point is attested by the numerous large boulders in the debris.

9. Section in well at Marietta:

1.	Sand and gravel	10	feet.
2.	Sand containing marine shells	2	"

10. Section 300 yards west of the portage on Hale's Passage:

1.	Soil	1	foot.
2.	Alternating strata of gravel and sand, the strata dipping in the bedding both east and west of the point where the section was taken	16	feet.
3.	Unstratified sand, containing boulders from the size of a pebble to a hundred tons weight	8	"
4.	Very light brown, very finely laminated, promiscuously bedded sand, having a wedge of gravel embedded in it. This sand was seen to pinch out in a short distance both to the east and to the west of the point where the section was taken,	6	inches.
5.	Gravel	2	"
6.	Very light brown sand	1	"
7.	Gravel and light gray, coarse sand, stratified, the striæ being wavy	1	foot.
8.	Laminated, fine, light brown sand, the laminæ very wavy and irregular	1	"
9.	Stratified sand, carrying cobblestones	1	"

11. Section on Bellingham bay, just east of Louis Tsetsatin's house, at the bridge, in section 36 of the Lummi reservation:

1.	Unstratified sand	7	feet.
2.	Blue clay, containing pebbles	6	"

12. Section in well one-fourth mile east of Mountain View:

1.	Clay and sand	14	feet.
2.	Stratum containing sea-shells	2	"

13. Section in Mr. F. C. Reeve's well, two miles east of Birch bay:

1.	Soil	2	feet.
2.	Yellow clay	20	"
3.	Bluish yellow clay	2	"

14. Section in Mr. Chambers's well, one mile east of Birch bay:

1.	White to yellow clay, containing pebbles and boulders	14	feet.
2.	Blue clay, containing sea-shells	6	"

15. Section in well one mile northeast of Birch bay:

1.	Gravelly soil	1 foot.
2.	Gravelly subsoil	2 feet.
3.	Blue clay	20 “
4.	Beach deposits, containing clam-shells	1 foot.

The water in this well is brackish.

16. Section on bluff opposite the railway curve on Semiahmoo bay, near Main street, in Blaine:

1.	Light brown sand, a sand-plain deposit of the Blaine esker	15 feet.
2.	Yellow clay	8 “
3.	Light blue clay	8 “

17. Section in a well opposite the schoolhouse in section 12, township 40, range 1 east:

1.	Clay	14 feet.
2.	Sea-beach gravel, containing boulders and marine clam-shells,	8 “

18. Section in a well in the northeast corner of section 18, township 40, range 1 east:

1.	Mostly quicksand. (The water of the well is brackish and has an iron-rust taste. It is poor boiler water)	10 feet.

19. Section in a well in British Columbia, one-fourth mile north of the northeast corner of section 35, township 40, range 2 east, in the United States:

1.	Clay	55 feet.
2.	Sand and gravel, containing sea-shells	5 “

20. Section in Mr. Waker's well in British Columbia, near the boundary line of section 31, township 40, range 3 east, in the United States:

1.	Clay	45 feet.
2.	Sand (cottonwood brush; sea-shells)	5 “

21. Section on the road six miles west of Abbott's Ford, British Columbia:

1.	Soil	1 foot.
2.	Stream-wash gravel	4 feet.
3.	Blue sand, coarse enough for plastering purposes	3 “
4.	Fine yellow sand	3 inches.
5.	Same as 3	4 “
6.	Same as 4	16 “
7.	Same as 3	6 “
8.	Fine yellow sand	4 “
9.	Blue sand, same as 3	4 “
10.	Minutely laminated fine white sand	4 feet.

22. Section 200 feet east of the last section:

1.	Gravel containing boulders	4 feet.
2.	Greenish, plaster sand	4 "
3.	Fine gravel	2 "

23. Section on the road 100 yards southeast of Abbott's Ford, British Columbia:

1.	Brownish red soil	3 feet.
2.	Sand containing cobblestones	12 "
3.	Cross-bedded coarse sand, containing gravel lenses	4 "
4.	Sand and gravel	5 "

24. Section on the road one mile northwest of Sumas lake (Eocene):

1.	Not seen	300 feet.
2.	Blue shale	10 "
3.	Lignite	2 "
4.	Dark shale	18 "
5.	Lignite	6 inches.
6.	Dark blue shale	20 feet.
7.	Yellowish, rather massive sandstone	100 "

Parties have tried to mine coal here at several different times; but the seams are too thin and there is too much dirt in the coal to make it pay.

25. Section four miles south of Murphy's Landing, on the Fraser (Eocene):

1.	Sandstone, shale, fire-clay, and very small seams of lignite (estimated)	500 feet.

26. Section just west of the railway-tracks at Sumas City:

1.	Sand and gravel	42 feet.
2.	Sandy gravel	40 "
3.	Sand	20 "

27. Section in a well in the southwest quarter of township 40, range 4 east:

1.	Light, sandy yellow clay	8 feet.
2.	Quicksand	4 "

28. Section on the road two and one-half miles east of Everson:

1.	Soil	3 feet.
2.	Coarse gravel	10 "
3.	Fine gravel	12 "
4.	Plastering sand	2 "

29. Section in road cut on the Bellingham northeast diagonal road, one mile south of Lawrence post-office:

1.	Sandy soil	2 feet.
2.	Sand	10 "
3.	Blue to yellow clay	15 "
4.	Blue clay	20 "

30. Section on the Bellingham road two miles southwest of Lawrence post-office:

1.	Soft blue clay	27 feet.

This clay has been tested and is said to be a good potter's clay. It is also said to be a good brick clay. In quantity it is almost inexhaustible.

At the base of this clay, 100 feet from the surface, in East Rome, near Lawrence post-office, gas was struck; but it was not in paying quantities.

FORMATIONS IN DETAIL.

Trap.—A trap-rock dike was found running in an east and west direction from near Abbott's Ford, British Columbia, to Sumas lake. It is composed of schist and serpentine rock, through which a ridge runs carrying gold, from fifty cents to a dollar and a half per ton. The height of the dike ridge is 500 feet (estimated).

Granite.—A patch of granite fills the triangle between the Sumas and Fraser rivers at their confluence. This area, which was examined only in a very general way, was found to contain iron-ore beds, the extent of which is yet undetermined.

Eocene-Miocene (marked Eocene on the map).—This formation is composed of light bluish gray to light buff sandstones and light gray to black carbonaceous shales, grading into seams of more or less impure coal. The measured thickness, according to Mr. Bailey Willis,[1] is 10,000 feet. The formation is much broken. Some earth blocks of it are raised to a high altitude, with the strata still practically horizontal, an example being the greater part of the Eocene area mapped in British Columbia; other earth blocks are pitched at a high angle, sometimes reaching or exceeding even ninety degrees. The formation seems to be of lake origin, the coal-measures of Eocene age; the series above the coal, Miocene. Prof. F. H. Knowlton, of the United States Geological Survey, after correlating the fossils of this formation, places its age as somewhere near the Middle Tertiary.[2] For a more detailed description of this formation, see Eocene Epoch[3] and Geology of the Coal-measures of Washington.[4]

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[1] Geological Survey of Washington, vol. I. part IV, p. 44.

[2] Preliminary Report on Fossil Plants from the State of Washington, collected by Henry Landes, 1901.

PLIOCENE.—A conglomerate rock was found in a little valley about four miles south of Murphy's Landing, on the Fraser river. A much larger area of the same kind of rock was found on the foot-hills just north of the Sumas mountains. It is undoubtedly much later in age than the Eocene-Miocene of the same region, because in British Columbia it fills a chasm left by the faulting of that formation. As no fossils were found, its age could not be determined. Its horizon, however, would seem to place it in the Pliocene.

GLACIAL.—The glacial deposits, which exceed 500 feet in thickness, are the surface rock of the entire region from the foot-hills to Georgian Bay, except where they are covered with recent deposits. They were deposited in the then Georgian Bay from the Mt. Baker and British Columbia glaciers. At the culmination of glacial times these two glaciers seem to have been one continuous ice-sheet thousands of feet thick which extended south probably to the Olympic mountains and westward to the Pacific;* but, as the epoch began to wane, they became separated and acted independently of each other. The Mt. Baker or Nooksack glacier then seems to have followed about the course of the Nooksack river to Lynden, and would have continued its course in a northwestern direction if it had not encountered the foot of the northern ice-sheet. This turned it in its course from a northwest to a southwest direction, causing a push-medial moraine, now a ridge, to be formed where the two glaciers came in contact, and a dump-terminal moraine from Blaine south to the portage along the Georgian Bay coast. The Fraser glacier at this time was stopped in its southern advance and turned westward by the granite trap and Eocene highlands in British Columbia, and further deflected westward by the Mt. Baker glacier. Its final dump moraine was probably in Georgian Bay, to the west of the present coast-line. On their final retreat from the region these two glaciers left elevated areas where their push-medial, terminal and lateral moraines had been; and estuaries or sounds between these and the foot-hills, all the country but the morainic strips being at or below sea-level. These strips are typically glacial, and present practically all the phenomena peculiar to a glacial region.

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[3] Landes, Washington Geological Survey, vol. I, part I, p. 29.

[4] Loc. cit., part IV, p. 43.

*This glacier passed over Orchis island, which is 1800 feet in height, the glacier stripping the island of practically all its soil.

SUBGLACIAL TILL.—This is a gray, blue or black clay. It is very hard, and when dry shows a joint structure. In many places it is a gumbo. At places where it is the surface rock it is very poor soil. It is of great thickness, and underlies the entire region to the foot-hills. It was deposited in sea-water, as its marine shells attest.

FOSSILS FROM THE SUBGLACIAL TILL.—The fossils figured and described here were taken from the subglacial till one mile below Fish Point, on the Bellingham Beach side of the Lummi Indian reservation.

Leda fossa (BAIRD). Figures 1*a* and 1*b*.

"Shell small, elongate, convex, thin; umbones anterior, turning[5] slightly toward the posterior end, which is elongated, narrow, and truncated; anterior end short and evenly rounded; sculpture nearly obsolete, a few concentric lines discernible; escutcheon long, narrow, smooth, and deep-set; an elongate process on middle of interior of posterior end; hinge with small internal cartilage pit, and numerous sharp teeth on each side."

Dimensions: Length, 15 mm.; alt., 8.5 mm.; diam., 5 mm.; umbo to posterior end, 10 mm.; to anterior end, 7 mm.

Distinguishable by lack of sculpture.

Living: Puget sound (Carpenter).

Pleistocene: San Pedro, Cal. (Arnold).

Leda hamata (CARPENTER). Figures 2*a* and 2*b*.

Shell similar to to *L. fossa*, except its surface is sculptured by strong concentric, raised lines; a raised band, strongly transversely sculptured by continuations of the concentric ridges, passes from the umbo around the escutcheon to the posterior end; escutcheon deep-set, smooth.

Dimensions: Length, 11 mm.; alt., 6 mm.; diam., 4 mm.; umbo to posterior end, 7.5 mm.; to anterior end, 5 mm.

Living: Santa Barbara to Catalina, Cal. (Carpenter).

Pleistocene: San Pedro and San Diego, Cal. (Arnold).

Pliocene: Deadman island, San Pedro, Cal. (Arnold).

Leda tenuisulcata (STIMP.) Figure 3.

Shell small, thin, elongate-triagonal, convex, somewhat inflated; umbones anterior, turning slightly toward the posterior end; shell rounded before, much elongated behind, the posterior length about twice the anterior. It is furnished with very fine, distinct, concentric striæ. A raised area, transversely sculptured by continuations of the concentric striæ, passes posteriorly on either side of the escutcheon from the umbones to the posterior margin of the shell. Both the anterior and posterior teeth are bent, the angle of eacl being directed toward the beak. Margin entire; cavity of shell rather deep. On the interior of the posterior end is an elongated, somewhat arrow-head shaped, raised process. The escutcheon is smooth.

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[5] Ralph Arnold's description; California Academy of Science, vol. III, p. 96.

Dimensions: Length, 6 mm.; height, 3 mm.; umbo to posterior end, 4 mm.; to anterior end, 2 mm.

Pecten (Chlamys) jordani (ARNOLD). Figure 4*a*.

Arnold's description:[6] "Shell of medium size, shape of *P. hericeus*, inequivalve, rather thin; right valve with twenty-five to thirty angular, smooth-topped, imbricated ribs, which become dichotomous after reaching a length of about 30 mm.; interspaces deeply channeled and narrower than the ribs; anterior ear imperfectly radially ribbed with six ridges, and showing elevated, concentric, incremental lines; posterior ear nearly obsolete, showing four ribs; byssal notch not deep; left valve shows twenty-five to thirty narrow, convex ribs, showing imbrications only slightly; interspaces as large as ribs; after a diameter of about 30 mm. has been reached by the shell, small riblets appear in the widening interspaces; anterior ear shows five narrow imbricated ridges, with wide interspaces; both valves show a tendency to contract suddenly at the basal margin upon nearing a completion of growth; surface of both valves covered with a minute, lattice-like sculpture which is generally worn off on exposed portions of the shell.

"Allied to *P. opuntia* (Dall.), but having fewer ribs on disk and ear, and having dichotomous ribs after reaching a diameter of 35 mm. Distinguished from *P. hericeus* and *P. hastatus* by not having fasciculated nor spinose ribs."

Pleistocene: San Pedro and Santa Barbara, Cal. (Arnold).

Pliocene: San Pedro and Santa Barbara, Deadman island, and Packard's Hill, Cal. (Arnold).

Dimensions: Length, 42 mm.; alt., 48 mm.

Pecten rubidos (HDS.) (?) Figures 5*a*, 5*b*, and 5*c*.

Shell of medium size; right valve with twenty-five to thirty broad, smooth-topped, very prominent imbricated ribs which become dichotomous after reaching a length of 45 mm. and also just before reaching the ventral margin; interspaces deeply channeled and narrower than the ribs; surface of shell covered with a minute latticework where not worn off, also by conspicuous growth lines near the margin; anterior ear imperfectly ribbed with four to six ridges, and showing elevated, concentric transverse ridges and incremental lines; posterior ear small, showing four ribs and conspicuous incremental lines; left valve not seen.

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[6] Loc. Cit., p. III.

This shell differs from *P.* (*Chlamys*) *jordani* in that the shell is larger and thicker, that its length and altitude are not the same, and that the ribs of the right valve, the valve seen, do not become dichotomous till they are about 45 mm. in length.

Dimensions: Length, 55 mm.; alt., 55 mm. (measure of 5*b*).

Septifer bifercatus (?). Figure 6.

The specimen given here is a fragment of the left valve. By a careful comparison with identified specimens it was doubtfully classed as above. Beds of these shells were found, but on account of their long interment they all crumbled to dust on exposure to the air. This fragment was saved with the greatest difficulty.

Tapes staminea (CONRAD). Figure 7.

Arnold's description:[7] "Shell of medium size and thickness, suboval, convex; surface sculptured with numerous crowded, rounded, radiating ridges and concentric lines, which are most prominent on the anterior end; no lunule; margin sometimes crenulated; hinge narrow; ligament narrow, long; three teeth in each valve; posterior two in right valve and middle one in left valve bifed; pallial sinus long, rounded; muscle impressions not sunken.

"This is a variable species; the shape of the shell and the sculpture varying in different individuals . . . "

Dimensions: Length, 20 mm.; alt., 14 mm.

Living: Straits of Fuca to Lower California (Cooper).

Pleistocene: Santa Barbara to San Diego, Cal. (Cooper); San Pedro, San Diego, Cal. (Arnold).

Pliocene: Santa Rosa; Twelve Mile House, San Mateo county, Kirker's Pass, Contra Costa county, Monterey and San Fernando, Cal. (Cooper); San Diego, Cal. (Arnold).

Miocene: West of San Jose; Foxin's, Santa Barbara county, California (Cooper).

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[7] Loc. cit., p. 150.

Cardium nuttallii (MART.) Figures 8*a* and 8*b*.

Shell medium size, cordate, inflated, equivalve; each valve with twenty-five to thirty angular imbricated ribs which seem to have been continuous from beak to dorsal margin (the surface of the shells obtained are much worn); interspaces wider than the ribs; surface marked with numerous transverse lines of growth; beaks prominent; abductor scars subequal, pallial line entire.

Dimensions: Length, 36 mm.; alt., 36 mm.

Living: Puget sound; Georgian Bay.

(?) **Abra** (?). Figure 9*a*.

The teeth, pallial line and muscular impressions having been removed from this shell, has made it impossible to identify it definitely.

Macoma nasuta (CONRAD). Figures 10*a* and 10*b*.

Arnold's description:[8] "Shell of medium size, ovate compressed, thin; anterior side dilated; posterior side cuneiform, extremity much above line of base; posterior dorsal margin straight to angle where it joins line of truncation; fold carinated on right valve; umbone slightly anterior to center, slightly prominent, narrow cardinal teeth in each valve; no laterals, ligament external, long, straight, narrow; pallial sinus large, expanding interiorly, that of left valve joining anterior muscle impression at its lower posterior angle.

"Distinguishable from *M. secta* by smaller size, less convex valves, less altitude, longer straight posterior margin, and larger, less prominent ligamental callus; from *M. inquinata* by larger, longer shell, less convex valves, less relative altitude, straight dorsal margin with truncation posteriorly, and by less central umbones; from *M. yaldiformis* by more cuneiform posterior extremity, long, straight, posterior dorsal margin, and by having beaks anterior to center rather than posterior; from *M. indentata* by beaks being more anterior, being broader, and by lacking the prominent folds, indentation of ventral margin, and prominent projection of posterior extremity; from *M. kelseyi*, which closely resembles it, by broader shell and by more oblique truncation of posterior extremity. . . ."

Dimensions: Length, 30 mm.; alt., 22 mm.

Living: Alaska to San Diego; Kamtschatka (Cooper).

Pleistocene: Santa Barbara to San Diego (Cooper); San Pedro; San Diego; Ventura (Arnold); Lummi; Blaine.

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[8] Loc. cit., p. 163.

Pliocene: Eagle Prairie and Danger creek, Humboldt county, California; Santa Rosa; San Fernando (Cooper); San Diego (Arnold).

Miocene: Sunol, Alameda county; Foxin's, Santa Barbara county, California (Cooper).

Macoma indentata (CARPENTER) (?). Figure 11.

Arnold's description (in part).[9] Shell rather narrow, suboval, compressed, thin; umbones slightly posterior to center; anterior end long and evenly rounded; posterior dorsal line straight; posterior extremity much projected and sharply rounded; fold prominent.

Dimensions: Length, 14 mm.; alt., 10.5 mm.; umbo to posterior extremity, 8.5 mm.; to anterior extremity, 10 mm.

This shell is like *M. indentata* described by Arnold, except it is much smaller.

Macoma inquinata (DESHAYES). Figure 12.

The only specimen obtained is the broken left valve represented in the figure.

Shell convex, thin; umbones subcentral; anterior end dilated; posterior end evenly arcuate from umbo and acutely rounded at posterior end.

Dimensions: Length, 11.5 mm.; alt., 8 mm.; umbo to anterior extremity, 7 mm.; to posterior extremity, 7 mm.

This shell is also much smaller than *M. inquinata* described by Arnold.[10]

Macoma concentrica (BURG.) Figure 13.

Though much broken, this shell was easily identified by comparing it with specimens in the university museum at Seattle. It resembles *M. nasuta* very much, except that its umbones are slightly posterior and the fold on right valve is less prominent.

Dimensions: Length, 33 mm.; alt., 22 mm.; thickness of right valve, 2.5 mm.; umbones to anterior extremity, 18 mm.; to posterior extremity, 15 mm.

Living: In Florida.

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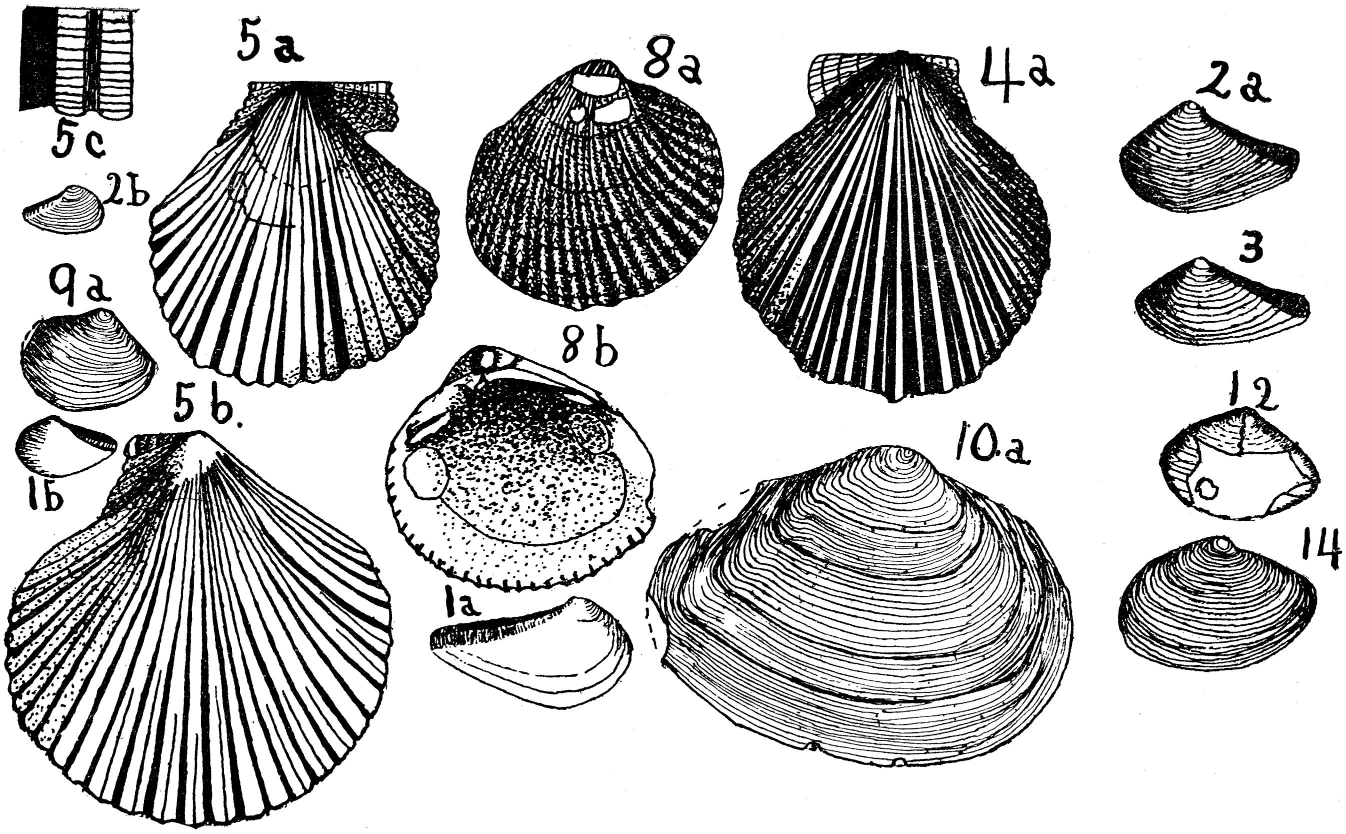
[9] Loc. cit., p. 161.

[10] Loc. cit., p. 162.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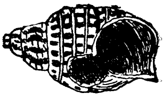

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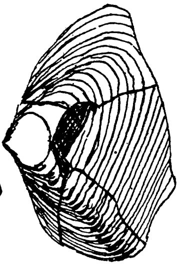

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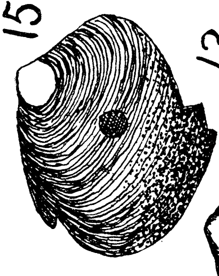

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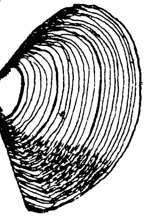

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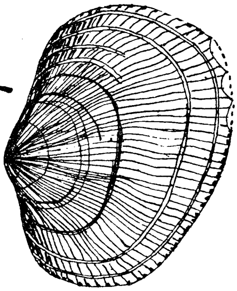

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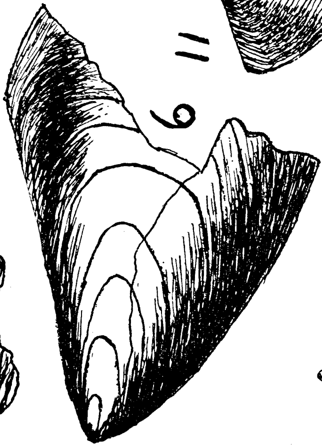

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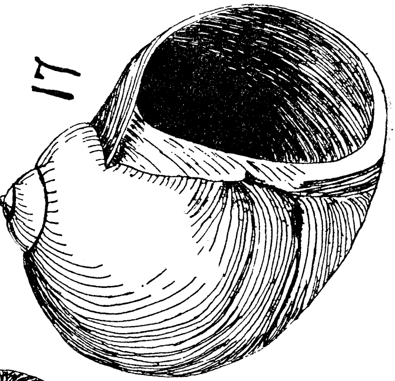

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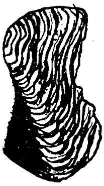

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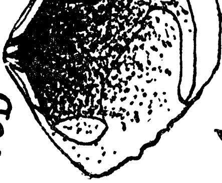
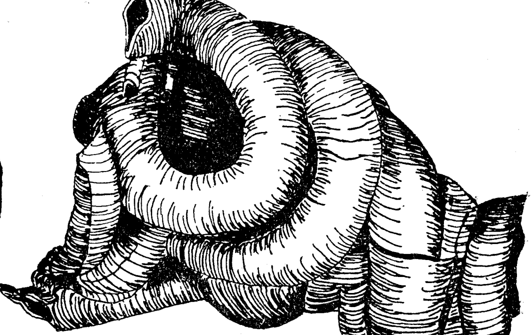


10b



18

EXPLANATION OF PLATES.

Leda fossa (Baird).
  1*a*. Right valve, 1–1.
  1*b*. Left valve, 1–2.

Leda hamata (Carpenter).
  2*a*. Left valve, 1–1.
  2*b*. Right valve, 1–2.

Leda tenuisulcata (Stimp.)
  3. Left valve, 1–1.

Pecten (Chlamys) jordani (Arnold).
  4*a*. Left valve, 1–2.

Pecten rubidos (Hds.) (?).
  5*a*. Left valve, 1–2.
  5*b*. Right valve of old specimen, 1–2.
  5*c*. An enlarged double rib of 5*b*, showing lines of growth, magnified.

Septifer bifercatus (?).
  6. Part of left valve, 1–1.

Tapes staminea (Conrad).
  7. Left valve, 1–1.

Cardium nuttallii (Mart.)
  8*a*. Right valve, 1–2.
  8*b*. Inside of right valve, 1–2.

(?) Abra (?).
  9*a*. Left valve, 1–1.

Macoma nasuta (Conrad).
  10*a*. Right valve, 1–1.
  10*b*. Inside of left valve, 1–2.

Macoma indentata (Carpenter) (?).
  11. Right valve, 1–1.

Macoma inquínata (Deshayes).
  12. A much broken left valve, 1–1.

Macoma concentrica (Burg.)
  13. Broken right valve, 1–2.

Macoma tampaensis (Conrad) (?).
  14. Left valve, 1–1.

Macoma yaldiformis (?).
  15. Broken left valve, 1–1.

Saxicava rugosa (Linn.)
  16. Right valve, 1–1.

Natica (Cryptonatica) clausa (Broderip and Sowerby).
  17. Drawing showing aperture, 1–1.

Vermetes species.
  18. Drawing, 1–1.

Ocinebra interfossa (Cpr.)
  19. Drawing showing aperture, 1–1.

Macoma tampaensis (CONRAD) (?). Figure 14.

Shell ovate, rather inflated, thin; umbones subcentral to slightly posterior to center; anterior end slightly rounder than posterior; no fold shown; ligamental area short, scooped out.

Dimensisions: Length, 13 mm.; diameter, 8 mm.; umbones to anterior extremity, 7.5 mm.; to posterior extremity, 6.5 mm.

Living: Gordon's Pass, Fla.

Macoma yaldiformis (?). Figure 15.

Shell ovate to elongate ovate, compressed, thin; anterior end dilated; posterior end slightly cuneiform, extremity somewhat truncated; posterior dorsal margin short, straight; fold carinated on right valve; umbones posterior; two (?) cardinal teeth in right valve (left valve not seen); ligament external, short, straight; pallial sinus large, wavy, expanding inside.

Dimensions: Length, 18 mm.; diam., 12 mm.; umbones to posterior end, 8 mm.; to anterior end, 11.5 mm.

Saxicava rugosa (LINN.) Figure 16.

Shell very variable in outline, generally angular oblong-ovate, convex, thick; surface ornamented with conspicuous concentric lines which give the surface a rugose appearance, these being more prominent along the angles of the shell; hinge area prominent; one prominent, well-forward tooth in the right valve (left valve not seen).

Dimensions: Length, 11 mm.; alt., 6 mm.; umbones to anterior extremity, 9 mm.; to posterior extremity, 3.5 mm.

Living: Port Orchard, Wash. (Kincaid).

Natica (Cryptonatica) clausa (BRODERIP AND SOWERBY). Figure 17.

Arnold's description:[11] "Shell of medium size, ovate-globular; spire only slightly elevated; whorls four, evenly convex, though sometimes slightly shouldered; surface smooth, except for fine incremental lines; suture impressed, distinct; aperture semilunar; outer lip sharp; inner lip callous and reflected completely over the umbilicus.

Living: Arctic ocean; Alaska; north Atlantic (Cooper).

Pleistocene: Santa Barbara to San Diego (Cooper); San Pedro; Santa Barbara (Arnold).

Pliocene: San Pedro, Santa Barbara (Arnold).

Dimensions: Alt., 27 mm.; lat., 26.5 mm.; aperture, 19.5x12 mm.

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[11] Loc. cit., p. 313.

Ocinebra interfossa (CPR.) Figure 19.

Shell fusiform; spire elevated; whorls five in number, each ornamented by five (and a trace of the sixth) rough, subangular, spiral lines which are very prominent on the anterior-posterior portion of the shell; also by cross-lines in the posterior portion and by incremental lines near suture; suture deeply appressed, distinct; aperture subelliptical; outer lip thickened; canal shallow, produced by an angulation of the lip.

Dimensions: Alt., 10 mm.; lat., 6 mm.; aperture, 5.5x4.5 mm.

Vermetes species. Figure 18.

Specimens of this species are abundant in this clay. They usually crumble, however, on exposure to the air.

ENGLACIAL AND SUBGLACIAL TILL.—This till covers practically the whole area, even the estuary regions, it being worked over wholly or in part in these regions by sea action. Its composition is principally sands and gravels to which a great number of boulders are added in the morainic regions. The formations of this till, the most conspicuous of which are marked on the map, are lateral moraines, dump-terminal moraines, push-medial moraines, kames, and kettle-holes, drumlins, ridge-eskers, overwash-marine delta deposits, etc.

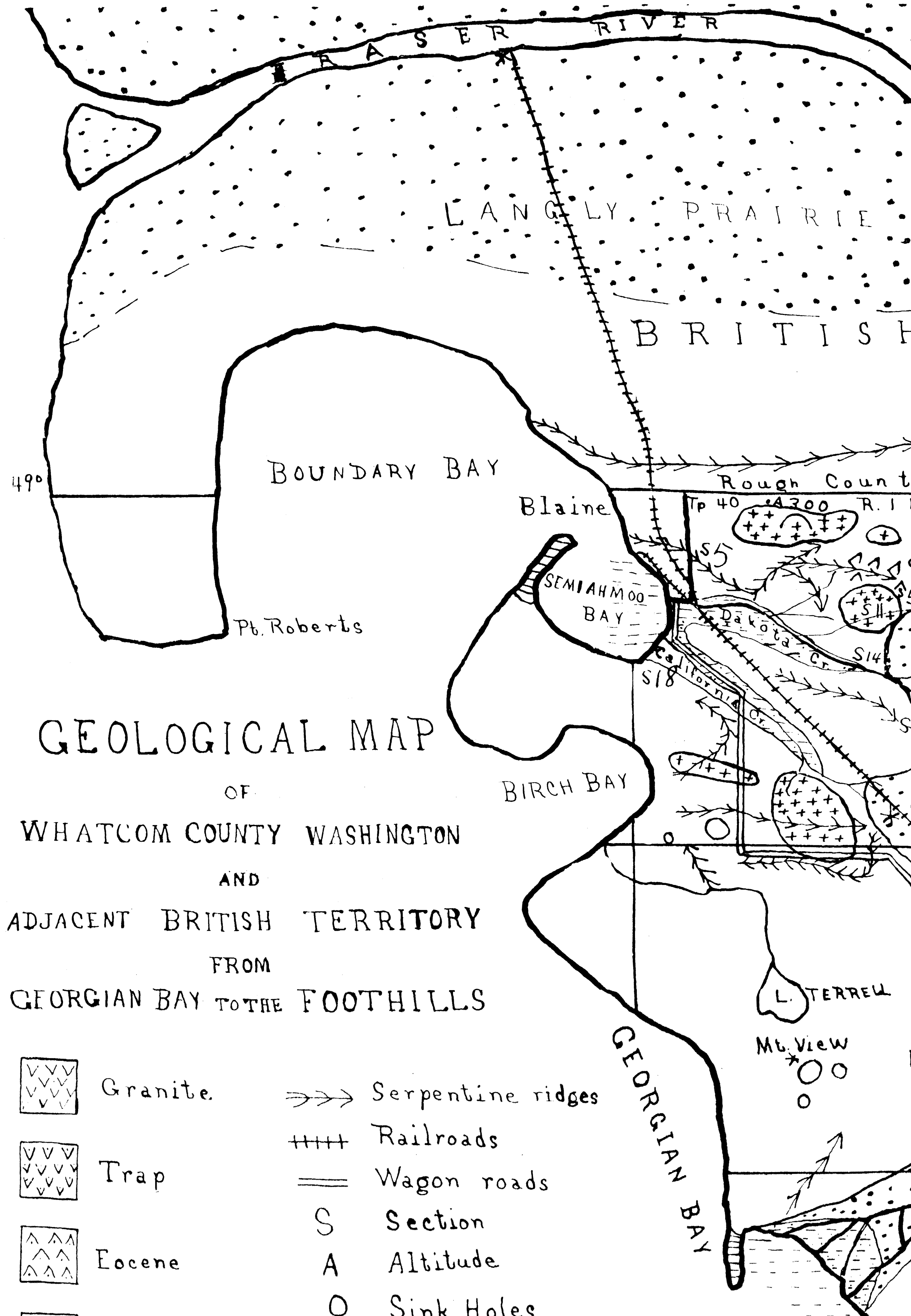
LATERAL MORAINES.—A ridge apparently of this type was observed southeast of the northeast diagonal road leading into Bellingham. It was not examined, but its position would seem to indicate that it was such a moraine.

DUMP-TERMINAL MORAINES.—A moraine of this type extended from Blaine south along Georgian Bay to the portage, the Lummi peninsula being the southern end of this moraine. Here boulders do not appear in great numbers on the surface, for reasons which will appear later; but at all places where the sea is making inroads into the land along the bay, the beach is strewn with granite and other plutonic "niggerheads." The foot of the glacier was sometimes further out to sea than the present morainic line; at other times further in on the estuary side. The different dumping-places left sink-holes between them, which are now kettles or lakes; Lake Terrel is an example.

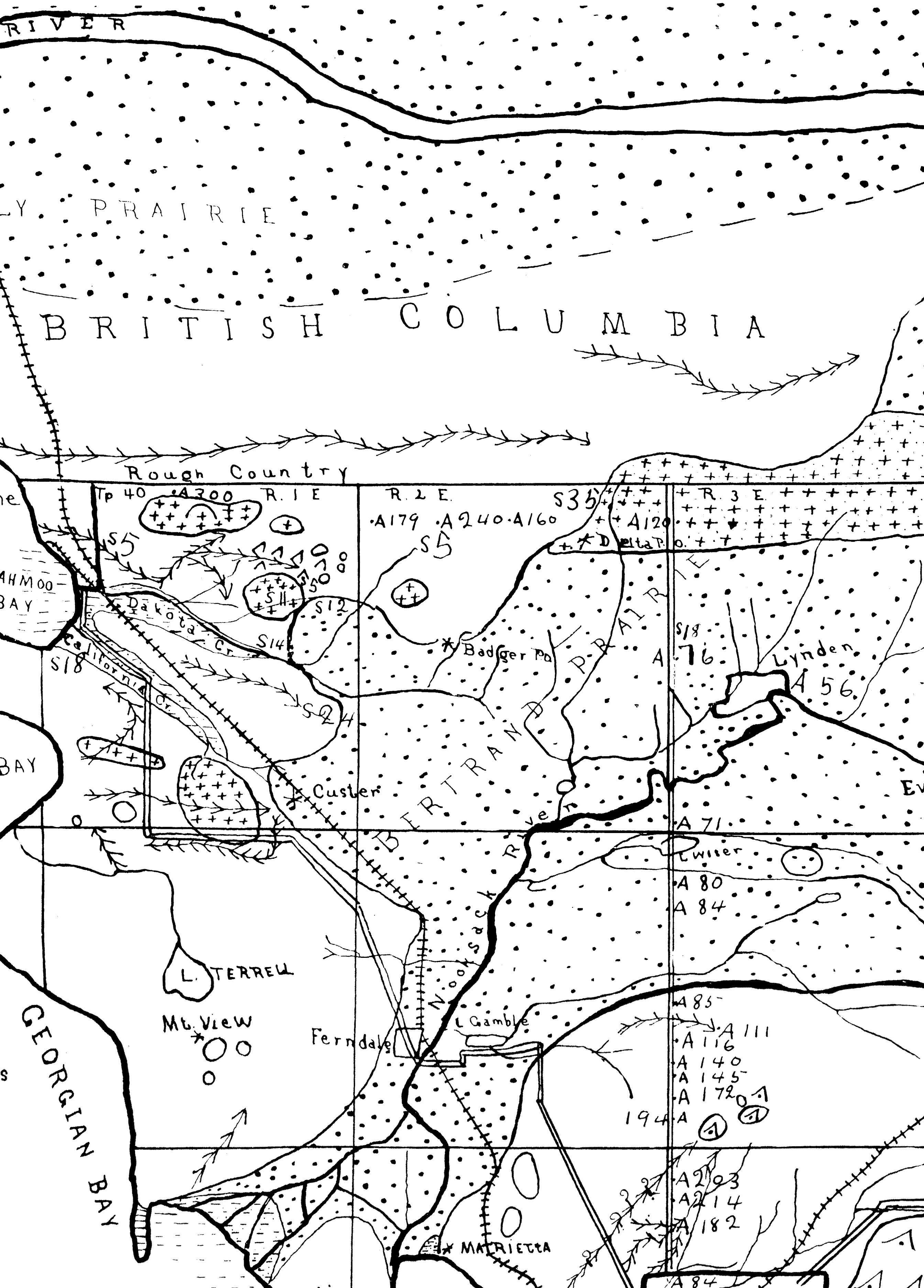
PUSH-MEDIAL MORAINES.—A morainic strip of this type, as we have seen, extends from near Sumas City and Abbott's Ford, in Canada West, to Boundary bay and Point Roberts. It was the middle ground between the two glaciers just before their final retreat. It is quite wide in places and constitutes the highest glacial deposits in the region. One hundred feet from the surface it was found to contain a large number of boulders and cobblestones, the remainder of its make-up being mostly gravel. Judging from the deposits, the glacier seems to have moved back and forth across this area several times, and near the close of the epoch it seems to have covered it entirely. At this time it seems to have formed a trough area between the two glaciers, and was consequently the dumping-ground. In it, both in the United States and Canada, esker rivers flowed to the sea; the largest south of the international boundary-line entered the bay at Blaine.

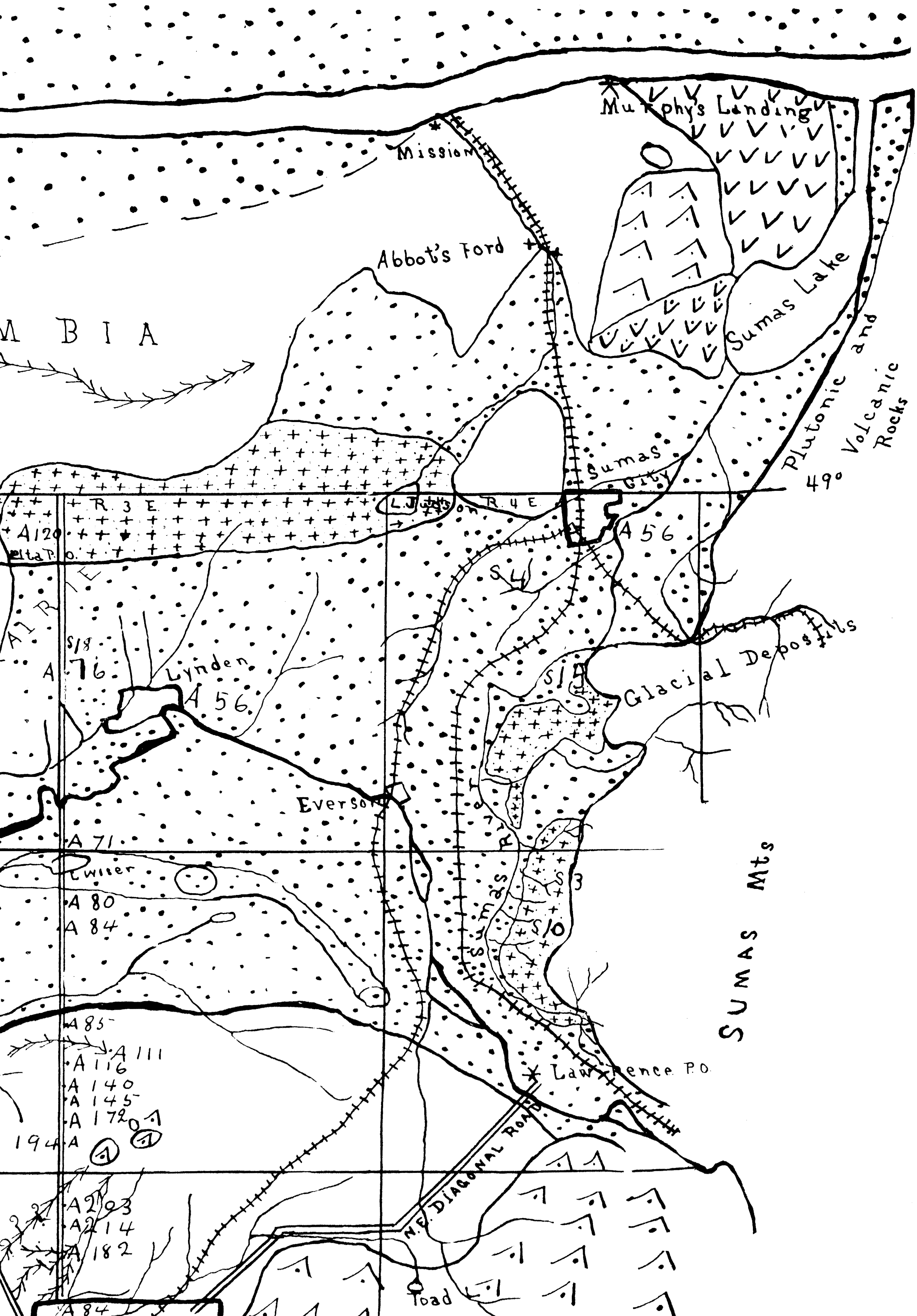
RIDGE-ESKERS.—Several ridges, most all of the serpentine type, are to be found in the region about Blaine and Custer and in the region just north of Bellingham. The long broken ridge in Canada seems to be an esker, but the country is too wooded to make a sufficient investigation to determine that it is. At all places where it was examined it was found to be composed of sand and gravel at its summit. An esker several miles long, standing up above the surrounding country like a railroad grade, has its sand plain in the suburbs of Blaine. Where it ends abruptly at the edge of the old Nooksack estuary it is forty-five feet higher than the land on which it is situated. Its course is serpentine, in a western direction. At a place or two it gives off ridges; at others ridges join it. It is composed mostly of gravel at its eastern terminus; but, as Blaine is neared, partly stratified sand becomes the predominant material. It was evidently deposited in a large superglacial stream—a stream that followed the normal course of the Nooksack river and reached the sea by the shortest route. Ridges of esker type cross the Parallel road several places between Bellingham and Lynden. Similar ridges were also seen at Custer and Mountain View.

KAMES AND KETTLE-HOLES.—In the push-medial morainic area east of Blaine in the inter-esker spaces the country is very knolly and contains many kettles. Most of the hills (marked drumlins on the map) seem to have been formed by the unequal melting of the ice at the glacial margin at the final retreat of the ice-sheet, the superimposed boulders and larger masses of till partially protecting the ice beneath them from melting. The unprotected portions of the ice would melt soonest, forming depressions. Into these the superimposed till on the protected areas would finally be dumped by lateral sliding; and, when the ice finally disappeared, would remain as kames (called drumlins by some writers). The portions of the ice that melted slowest would now represent kettle-

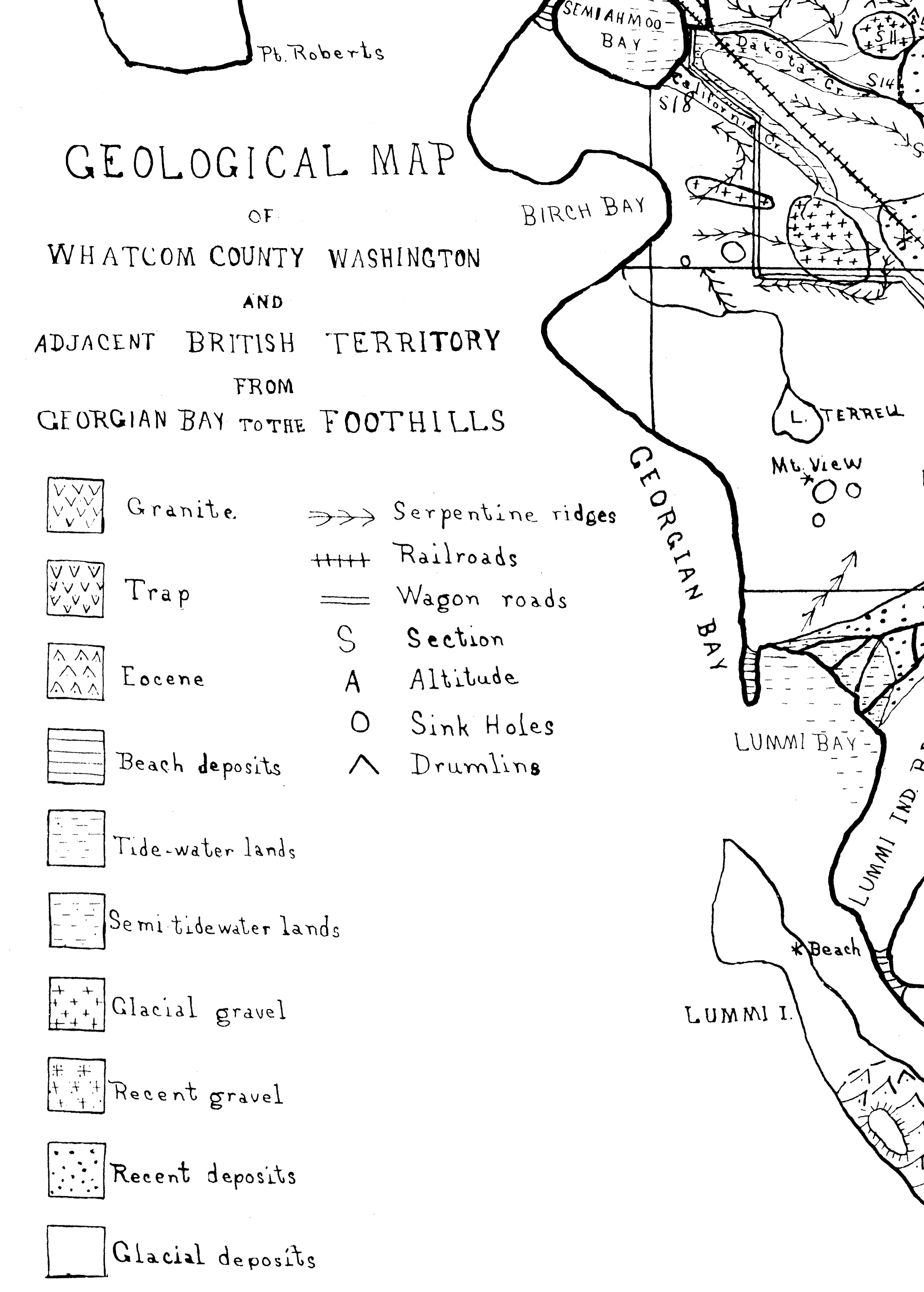


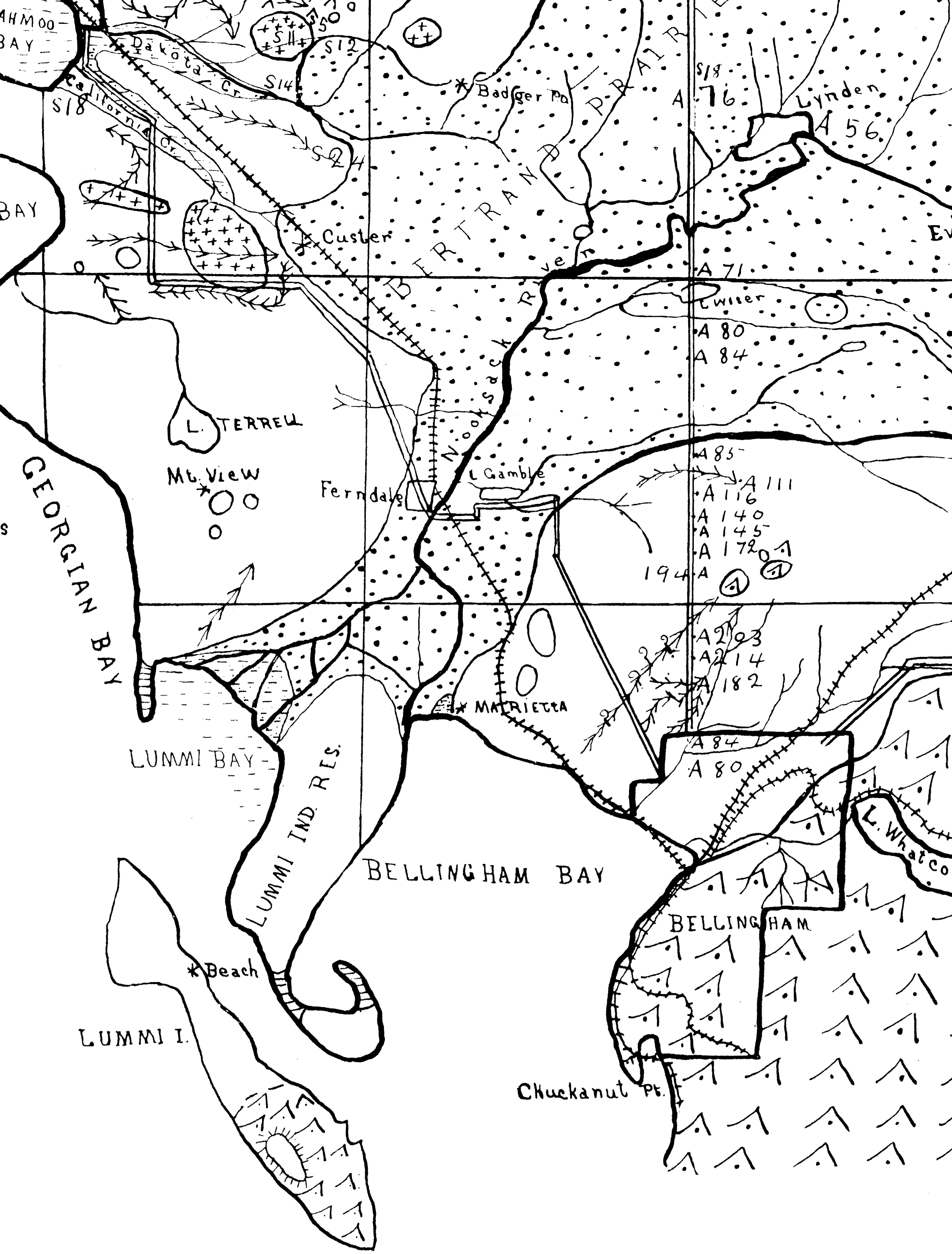
GEOLOGICAL MAP
OF
WHATCOM COUNTY WASHINGTON
AND
ADJACENT BRITISH TERRITORY
FROM
GEORGIAN BAY TO THE FOOTHILLS

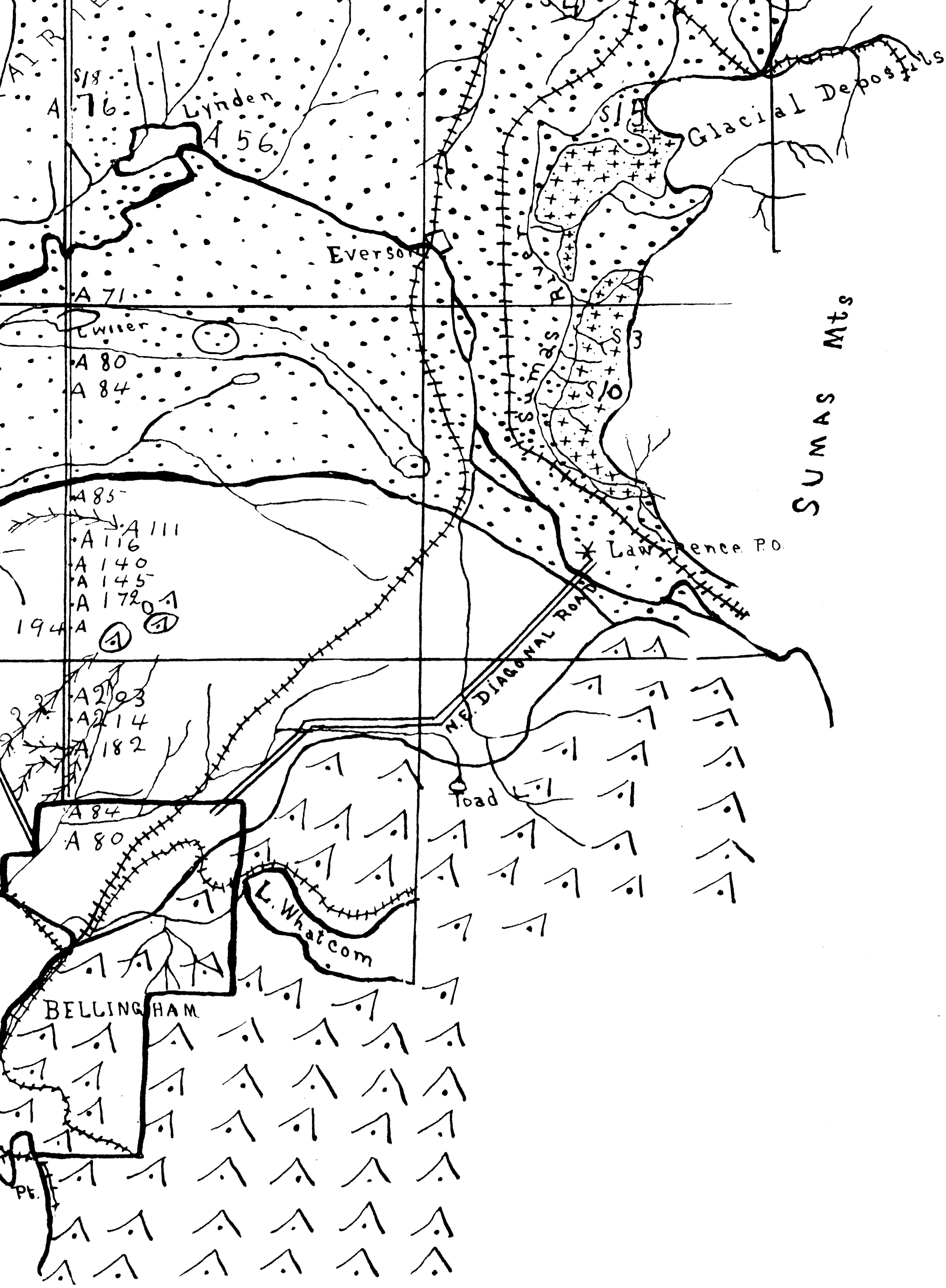

RIVER
LY PRAIRIE
BRITISH COLUMBIA
Rough Country
Tp 40
A300
R. 1 E
R. 2 E
R. 3 E
A179
A240
A160
S35
A120
Delta P.O.
he
S5
S5
AHMOO
BAY
S11
S50
S12
Dakota Cr.
S14
California Cr.
S18
S24
BAY
Badger P.O.
BERTRAND PRAIRIE
S18
A76
Lynden
A56
Custer
Nooksack River
Ev
A71
Twiser
A80
A84
L. TERRELL
Mt. View
GEORGIAN BAY
s
Ferndale
L Gamble
A85
A111
A116
A140
A145
A172
194 A
A203
A214
A182
MARIETTA
A84


Murphy's Landing
Mission
Abbot's Ford
M B I A
Sumas Lake
Plutonic and Volcanic Rocks
Sumas City
49°
R 3 E
L. Judson
R 4 E
A 120
lta P.O.
A I R I E
A 56
S 4
S 18
A 76
Lynden
A 56
S 18
Glacial Deposits
Everson
A 71
Twiner
A 80
A 84
S 3
Sumas R
S 10
Sumas Mts
SUMAS
Lawrence P.O.
N.E. DIAGONAL ROAD
A 85
A 111
A 116
A 140
A 145
A 172
194 A
A 203
A 214
A 182
A 84
Toad

GEOLOGICAL MAP
OF
WHATCOM COUNTY WASHINGTON
AND
ADJACENT BRITISH TERRITORY
FROM
GEORGIAN BAY TO THE FOOTHILLS




AHMOO
BAY
S50
S11
S12
Dakota Cr.
S14
California Cr.
S18
S24
Badger Po
S18
A 76
BERTRAND PRAIR
Lynden
A 56
BAY
Custer
Nooksack River
Ev
A 71
Twiter
A 80
A 84
L. TERRELL
Mt. View
Ferndale
L. Gamble
A 85
A 111
A 116
A 140
A 145
A 172
194 A
GEORGIAN BAY
S
A 203
A 214
A 182
MARIETTA
LUMMI BAY
LUMMI IND. RES.
A 84
A 80
L. Whatco
BELLINGHAM BAY
BELLINGHAM
Beach
LUMMI I.
Chuckanut Pt.


S18
A 76
Lynden
A 56
Everson
A 71
Ewiser
A 80
A 84
A 85
A 111
A 116
A 140
A 145
A 172
194 A
A 203
A 214
A 182
A 84
A 80
BELLINGHAM
L. Whatcom
Pt.
Toad
N.E. DIAGONAL ROAD
Lawrence P.O
Sumas R
S19
S3
S10
Glacial Deposits
SUMAS Mts

holes. These kame-hills and kettles also seem to be intimately connected in origin with the ice edge and to be due to marginal conditions, such as the incorporation of ice fragments in the till, the grounding of blocks of ice, the movement of the ice edge, and the development of underground ice-sheets. Similar kames and kettles were also found in other parts of the glaciated region. Several kettles were noticed at Mountain View.

DRUMLINS.—There are several boat-shaped knolls and ridges east and north of Bellingham in the lee of the now existing Eocene-capped hills, or of some projecting hard substance now beneath the surface which resisted the wear and erosion of the ice. These hills seem to have collected in a way similar to the way snow drifts behind a wind obstruction, except that they were closed in at the top and on the sides by ice.

SAND-PLAINS.—There are several sand-plains in the region, but the only one specially noticed is that at Blaine, previously mentioned.

OVERWASH AND GLACIAL MARINE DELTA DEPOSITS.—These are given together here because the first merges into the second. The whole area south of Blaine, except the estuary part, is covered with overwash material which was deposited at or just below sea-level, as is attested by the marine fossils. It is composed mostly of sand, and ranges from a few inches to several feet in thickness. On the Lummi peninsula, south of Fish Point, it was found to have been dumped into the sea beyond the terminal moraine. There it accumulated to a great thickness.

RECENT DEPOSITS.—These are: Tide-water, semitide-water, beach, delta, estuary, lake and swamp deposits.

TIDE-WATER DEPOSITS.—These cover the area between high and low tide-water marks both at the heads of Bellingham and Lummi bays. They are composed mostly of sand. They are valued principally for the setting of salmon nets and fish-traps, and for their clam-beds.

SEMITIDE-WATER LANDS.—These lands are situated at the mouth of the Lummi river, and in the vicinity and to the northwest of Marietta. They are flats over which high tides sometimes flood. They are composed of marine sand and silt. They are seepy, sour areas, which are mostly worthless.

BEACH DEPOSITS.—These form the spits of the region, also the narrow neck of land at the portage, and a narrow strip along the coast in the vicinity of the government day-school building.

They are composed mostly of gravel and cobblestones. The spit at Blaine is used as a site for fish canneries. The other spits are used as camping-places in the fishing season.

DELTA DEPOSITS.—These cover large areas both at the mouth of the Fraser and the Nooksack-Lummi rivers. The Nooksack delta is quite thick. Logs in it have been found thirty feet beneath the surface. This delta, where it is not swampy, contains some of the best farms of the region. There are also some fine farming sections in the Fraser delta.

ESTUARY DEPOSITS.—These are found in the valleys of the Fraser and Nooksack rivers, above the respective deltas. As has been stated, these regions were at or below sea-level at the close of glacial times. While thus depressed a coarse, ash-gray sand was spread over the Nooksack estuary from a few inches to many feet in thickness. The thickest deposit of this sand is on the west or slack-water shore of the estuary (the glacial sands are finer and are all brown to light yellow in color). While this sand was being deposited in the slack-water region away from the mouth of the Nooksack river, that river was depositing gravel on the current side. Besides that the waves of the estuary were forming beach gravel by their pounding against the walls of the Sumas mountains on the east and by their tearing down and leaching out the finer material of the glacial deposits of the push-medial moraine to the northwest, the coarser material being left behind as gravel and cobblestones. That these deposits were laid down in sea-water is attested by the fact that they all contain marine shells. Sea-shells were found in them seventy feet above present sea-level. The sites of these estuaries are now occupied, in part, by low prairies; the Bertrand prairie is situated in the Nooksack estuary, the Langly prairie in the Fraser.

LAKE DEPOSITS.—Deposits of this type are often very thick. They are composed mostly of sand, silt, and peat.

SWAMP DEPOSITS: These cover a great part of the delta and estuary areas and are also found bordering the glacial lakes. The swamps of to-day, however, cover a much less area. The deposits are composed mostly of black muck and peat. When tiled the swamp regions make fine farming lands.

LAKES.

The lakes, besides Lake Whatcom (of which no examination was made), are Wiser, Gamble, Terrell, Judson, and Sumas.

Wiser lake is the lower end of a low area which seems to be an abandoned channel of the Nooksack river; its upper end is now a swamp. The whole area empties its surplus water into the Nooksack through a small stream which connects with the lake. The lake is from thirty to fifty feet deep. It was once much larger than at present. It is now surrounded by a marsh. In this the peat deposit is very thick; at places it is over twenty feet. The peat west of the lake covers over 400 acres. This is being ditched and will soon be farmed.

Gamble lake seems to be a closed slough of the Nooksack — an abandoned channel from which a small stream flows to the river.

Lake Terrrell was caused by the terminal moraine making a second halt in its retreat here; the space between the two dumping-grounds is now occupied by the lake. This lake, which is now very shallow, has had about three times its present dimensions. The prevailing wind which has blown over it has been from the northeast; this has caused the waves to etch away the bluffs on its west and southwest sides. This chopping process finally cut an outlet. In the etching-out process the finer material was carried back into the lake and has been no small factor in filling it up. The coarser sand and boulders were left behind on the lake front as a characteristic lake deposit. On account of the filling up of the lake and the lowering of its level by its having cut an outlet, much of the area mapped is a swamp. In this, peat has deposited to a depth of three feet. This swamp region is now being reclaimed by ditching and tiling.

Some years ago a man attempted to drain this lake in order to take its site as a homestead. He was promptly stopped, however.

Judson lake, situated in the Nooksack valley, was caused by a beach bench of the Nooksack estuary damming its natural outlet. Its surplus water now flows north by way of Abbott's Ford to the Fraser.

Sumas lake is the remains of the Nooksack-Fraser estuary (or sound). It is now the back-water region of the latter stream; its area varies with the rise and fall of that river. It often extends as far south as Sumas City. It is very shallow except in its central part. At the time visited a company was being formed to dike it at the south. This, it was claimed, would reclaim 100,000 acres, all of which would evidently make good farm land, as its surface is composed of a stratum of peat from six inches to a foot in thickness.

STREAMS.

The principal streams of the region are the Fraser and Nooksack rivers, and the Dakota, California and Terrell creeks, and their tributaries.

The California and Dakota creeks are both flat-bottomed, wide-mouthed, mud-flat streams that are practically dry when the tide is out. They both have their source on the low divide between the Bay of Georgia and the Nooksack valley at this point. In fact, they have cut their channels back till they rise in the Nooksack valley. At one time they seem to have been channels leading out from the Nooksack estuary. They both pour their muddy waters into Semiahmoo bay.

The creek that drains Lake Judson flows out of the Nooksack valley proper, through a gorge in the glacial deposits, to the Fraser, at Mission.

The Fraser river descends from the mountains and crosses the Sumas valley and then passes through granite walls to the flats beyond, through which it flows to Georgian Bay. It is a large river, of rapid current, and is navigable to the foot-hills.

The Nooksack, a much smaller stream than the Fraser, flows from the foot-hills in a northwest direction to Lynden. At this point it turns abruptly southwestward, which direction it keeps till it reaches the point where it forms its delta. Here it divides and subdivides. The main branch empties into Bellingham bay; the minor branch into the Bay of Lummi, on the opposite side of the Lummi peninsula. On leaving the mountains it has a very rapid current, but below Lynden the stream is so near base-level that its rate of flow is much reduced. In its lower course its channels are very changeable. A change in the main channel in the '80's washed away most of the Indian village of Lummi and compelled the government to move its school buildings to save them; the site of the schoolhouse then is now in the center of the main channel of the river. A jam in the river some years ago flooded the whole country and did great damage to property. Had it not been removed by the government it would have ruined all the delta farm lands and in the end would have changed the main channel of the river to the Lummi bay side of the peninsula. This would have ruined the fishing industry of the Indians and of the white people at Marietta. The river is navigable for small boats to Lynden.

DID THE FRASER RIVER EVER FLOW THROUGH THE NOOKSACK VALLEY?

As has been previously stated, a large estuary or sound once extended up the Nooksack valley from Bellingham bay to the Sumas mountains. An arm of this sound was found to have extended north through the Sumas valley to the Fraser river, both streams then emptying into the same arm of Georgian Bay. The Fraser estuary or sound also then existed; the gap in granite barrier to the Fraser's western outlet was then probably partly cut. Probably this estuary and the Nooksack sound were one continuous sheet of water; the land west of it islands. As the country was gradually elevated above the sea the continuous sound became a swamp area and then dry land. At first the Frazer sent at least a large part of its water through the Nooksack valley to Bellingham bay; the Nooksack was then a tributary of the Fraser. The part of the Fraser, if any, flowing westward, made its way over a fall where it crosses the granite ledge that closes in the Sumas valley. As the elevation was continued, and the barrier to the western outlet of the Fraser was more and more reduced, a greater volume of that river found its way westward. Finally, as it was the larger stream and consequently could erode faster than the Nooksack, it reduced its channel to the same level at the Sumas pass as the Nooksack was at Lynden. This caused a slackened-water, or laken, region to exist between the two streams. As the Fraser crossed the narrowest part of this lake it soon filled that part of it with sediment, only a small stream connecting the lake with it, and all of the water of river found its way westward. On the other hand, the Nooksack entered the broad, shallow end of the lake, or sound, if it still continued to be a part of the ocean, on leaving the foot-hills, and there deposited its sediment in the form of a semicircular ring ten to twelve feet in height completely through the lake. The tide, coming up the outlet of the lake, or up the sound, if the Nooksack valley still remained a sound, probably aided in forming this ridge. The lowering of the stream below the lake lowered the surface of the lake, and left the ridge dry land, with the Nooksack to the south of it. This ridge is to-day the watershed between the two streams. The facts that lead up to this conclusion are these: (*a*) Throughout the level area from Lynden to Sumas lake all the wells are drive-wells, ranging from fifteen to forty feet in depth. The strata through which they are driven are sand and gravel of the river type, the depth of which is unknown. (*b*) The Sumas river, which flows almost parallel with the Nooksack river for several miles, is at the same level as that river, and is separated from it in many places only by the low ridge previously mentioned. At Everson the Nooksack runs on one side of the depot, and the drainage of the other side is through the Sumas to the Fraser. In fact, it would not take 100 men one day with team and scraper to so change the channel of the Nooksack, at any one of several places, during high-water times, that a great part of its water would ultimately reach Georgian Bay through the Fraser. And the same is true of the latter stream during flood periods. It would back its water up through the Sumas into the Nooksack. In 1894 it flooded the Sumas prairie so that boatmen rowed to the suburbs of Sumas City in the slack water. When visited in June last it was backing water over the prairie within two miles of that city, and the Sumas river was at a stand-still at Everson. There seems to be every reason to believe that should these two streams—Nooksack and Fraser—get on a "rampage" at the same time they would flood the entire flat country between them.

DID THE NOOKSACK RIVER EVER FLOW THROUGH THE SUMAS VALLEY TO THE FRASER?

To this question a negative answer can assuredly be given. Had it ever flowed there it would still do so, because, with the low divide removed, as it would then have been, the fall is decidedly northward.

POSSIBLE CAPTURE OF THE NOOKSACK RIVER BY THE FRASER.

The Fraser, on account of its volume and fall in its upper part, is eroding its channel faster than the Nooksack, and has already captured several streams in the valley of the latter. As we have seen, Lake Judson, just north of the low dividing ridge, drains into it, as does also the Sumas river, a river which rises in the very gorge through which the Nooksack descends from the mountains, and which flows almost parallel with it and at about the same level for miles. Furthermore, a very high flood, now that the timber is mostly removed, may at any time cause the Nooksack river to cut through the low divide and turn the greater part of its water into the Fraser through the Sumas river and lake. Such a catastrophe is expected by the settlers at every flood period.[12]

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[12] The removal of a few feet of the divide west of Lynden would turn a portion of the Nooksack river into Semiahmoo bay through the Dakota creek.

CANALS.

If the people of this region were a water-going people, like the Hollanders, they would have canals running over the country in every direction. A canal connecting the Nooksack and Fraser rivers through the Sumas river and lake route could be easily constructed, large enough to accommodate large gasoline boats; and by the use of locks still larger vessels could be used. Another canal could be almost as easily cut from the bend in the Nooksack river west of Lynden to Blaine through the Dakota creek.

WATER POWER.

No attempt was made at an investigation of this subject. It is very evident, however, that both the Nooksack river and the stream that drains Lake Whatcom—a stream about forty feet wide and having a fall of 318 feet in about three miles, would furnish a great amount of water power. The writer was told that the Bellingham Bay & Eastern railway has a power plant of 10,000 horse-power near Nooksack falls, about fifty-two miles by rail from the city of Bellingham; also that mills were operating on Whatcom creek, in the suburbs of Bellingham. For a complete discussion of this subject, see Professor Landes's report.[13]

WATER.

The water of the Nooksack river and of Lake Whatcom is good drinking water, and also good water for use in boilers. The water in the swampy regions is dark, similar to the color that water has in a barn-yard drain. It is very unwholesome. The water in all the wells near the seashore or in low areas, except in the Nooksack-Sumas prairie region, is brackish, and unfit for use. All the wells in the Sumas valley that have their source in the underlying quicksand and gravel are soft and potable, and most always good water for use in boilers. The water at several places in the Bertrand prairie was found to contain considerable iron and was "hard on boilers," to use the common phrase. All the spring-water examined was pleasant to the taste.

SPRINGS.

The springs are found along the foot-hills and at the heads of the streams having their sources in this region; also in the Mountain View country and in and at the edge of the highland east of Blaine. All the springs are small and none possess medicinal properties.

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[13] Loc. cit., part V, pp. 32, 33.

WELLS.

The drinking water of all the region back from the main streams is furnished by comparatively shallow wells. The wells in the Sumas valley and in the vicinity of Lynden and Everson are drive-wells, as previously stated, the water being found in gravel and sand. The wells in the vicinity of Mountain View are dug in subglacial till that is so hard that it has to be blasted. This clay is non-porous and the wells dug in it are mere cisterns, the eaves of the houses or barns usually furnishing the water.

MINERALS.

SAND.— Glacial sand covers all the highlands from Blaine to the portage. It is a light brown, usually very fine sand. Some of it is good for plastering purposes, but most of it is too fine. A great deal of it would make good molding sand, and would also be good in city paving and in macadamizing roads. The soil of the region over which this sand is spread is very poor.

The ash-gray sand of the delta formation is coarse, and is, consequently, good plastering sand. Large areas of it are found between Custer and Ferndale. It is of great depth in these localities, and, as the railway crosses them, it could be easily shipped.

GRAVEL.— Extensive gravel areas occur at several places, the locations and approximate areas of which are marked on the map, but not their outline in detail. Some of the gravel deposits are glacial in origin; others, estuary and beach deposits; and those west, and in the vicinity of Lake Judson, worked over or repiled glacial material. A great part of the gravel was found in low sections; but the gravel in Canada and that just east of Blaine is on high land. On the whole the gravel is a coarse variety in which are embedded many cobbles and boulders. It is now being used extensively for macadamizing roads; and, as the supply is inexhaustible, there is no reason why this region should not have first-class roads in a few years.

GARNETS.—Garnets are found on both beaches of the Lummi peninsula. They are obtained from the schists, principally from the mica schists. These schists on weathering and crumbling to dust on the highlands leave the harder garnets to be carried to the shore line by the streams. Here they are found in the beach sand. Garnets are also found at several places in the glacial deposits.

GOLD.—The black sand of the Lummi Bay beach carries gold; but there is so much verdigris in the water and sand that it is difficult to wash it out. So far there has not been enough found to make it pay.

COAL.—The coal seams examined in British Columbia were all coal of the lignitic type. At one place several tunnels had been made and coal had been mined at several different times, but had each been abandoned; the seams were too thin and the coal contained too much dirt. Probably by sinking shafts, thicker veins and a better quality of coal could be obtained.

The Eocene formation in the vicinity of Bellingham contains several coal-seams of workable coal; but a study of them and of the mines of the region was not made by the writer. A description of them, however, may be found in Professor Landes's report.[13]

SOIL.

The soil is very variable. In the glacial overwash regions it may vary from a few inches of loam to sand, gravel and clay all in the same dooryard. On the highlands east of Blaine, except in the sand and gravel districts, it is usually good. In the Sumas valley about Sumas City it is so light that it is blown from stumps, leaving the roots bare. In the immediate vicinity of Sumas City and lake it is deep, and ranges from a dark black muck to peat, from six inches to three feet in thickness. In all the swamp areas it is decayed peat.

The region is fast becoming a farming section.

Loc. cit., part I, p. 47.